

MODIS "Golden" Questions  
Hoge  
Oct 15, 1989

# ATTACHMENTS

1. Salomonson IWG Input letter to MODIS Team members
2. Salomonson letter to Facility Instrument Team Leaders
3. Fundamental Questions (NEED YOUR COMMENTS)
4. Priority Framework (NEEDS YOUR ASSESSMENT)
5. Support Comments (NEED YOUR COMMENTS)
6. Products & Accuracies (NEED YOUR PROPOSED REVISIONS)
7. Salomonson Specifications letter to Team Members
8. Specifications (NEED YOUR COMMENTS)

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**PLEASE FORWARD YOUR INPUT TO LOCKE  
STUART (GSFC MAIL: LSTUART) SO THAT IT IS  
RECEIVED BY NOVEMBER 15!**

**IF YOU ARE TELEPHONING YOUR INPUT,  
LOCKE STUART MAY BE REACHED AT (301)  
286-5411. ALTERNATIVELY YOU MAY  
CONTACT BILL BARNES [(301) 286-8117] OR  
VINCE SALOMONSON [(301) 286-8601].**

AS = Alan Shablier  
AH = Alfred Huete  
MK = Mike King  
FH = Frank Hoge  
MA = Mark Abbott  
HG = Howard Gordon  
YK = Yoram Kaufman  
LTF = Lidia Tarr  
JP = Joan Parslow

WZ = Wan Ziesendorf  
SR = Steve Ruenig  
CJ = Chris Justice

To: MODIS Team Members  
From: V. V. Salomonson  
Subject: Input for the Eos IWG/SEC/Facilities Instrument Panel and Payload Recommendations Panel

At the last Investigators Working Group (IWG) meeting in Pasadena some of the efforts to have the principal questions of global change prepared were enhanced. You have seen some indications in past MODIS Team activities along this line in terms of framing five (that is the upper limit) of the highest or most prominent questions that each Eos facility and principal investigator instrument will address. As part of the activities of the Science Executive Panel (SEC) of the IWG, of which I am a member, I was charged to collect the appropriate responses (questions plus other items) from the Facility Instrument Team Leaders. Attached is the communication that I have sent to all the Facility Team Leaders very recently.

Enclosed in this total package is the material that I have developed or collected in preparing the MODIS response to the attached instructions. Some companion statements about this material follow .

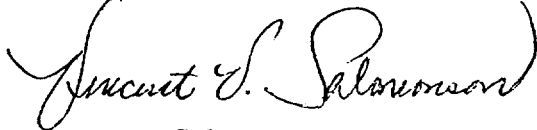
- a. The five questions/areas of global change to be addressed by MODIS should be examined by everyone and suggested changes sent back to me by the due date indicated at the end of this letter.
- b. The contributions of MODIS to the subjects indicated in the Committee on Earth Sciences (CES) priorities chart have been provided by asterisks for essential (\*) and contributing (\*\*). Please read the CES document and the rough draft supportive comments that have been included in this document and, as above, send them back to by whatever means of communication you wish.
- c. The Table of products and accuracies is to be considered by all of you as something for you to make revisions as you see fit. The most critical part of this table is the accuracies (on a pixel basis for observational, as opposed to model, products). These accuracies will be compared to accuracies and products required or desired by the Interdisciplinary Teams representing the scientific community at large. Therefore, it is important that they are defensible.

With regard to the last statement in the preceding paragraph, the CORE PRODUCTS document has been prepared by a contractor team in support of Dr. D. Han's (GSFC) management of the MODIS data processing requirements studies. This document is provided for the purpose of reflecting the contractors' reading of the literature and, from that reading, an estimate of accuracies achievable now and in the future when MODIS is available. I am sure there are items that are not quite right, but I need your opinions to buttress or correct my opinions.

The "bottom line" here is that we need your best attempts or inputs by November 15 with regard to items a-c described above. I believe that we will have further opportunities and time to work on these things (such as the next Team meeting now being examined for possibly occurring in late January), but it is crucial that our best input be developed by November 15 so that Berrien Moore and his Payload Recommendations Panel can work on whatever they have in late November. Berrien will be striving to mesh science priorities with the contributions of the various instruments so as to develop recommendations to the Eos Project and Program about what instruments should be included on the various platforms (it may be well to note, for emphasis, that there are more instruments than can be included on the platforms, and, probably, more instruments than can be afforded in any

case). So, please do the best you can in the time you have available. I know that you are all quite busy and underfunded, etc., but whatever you can do will be appreciated. The attached letter provides all the various ways you can send messages to me.

Thanks, in advance, for your efforts.

A handwritten signature in cursive script, reading "Vincent V. Salomonson". The signature is written in dark ink and is positioned above the printed name.

Vincent V. Salomonson  
MODIS Team Leader

To: Facility Instrument Team Leaders  
From: V. V. Salomonson  
Subject: Inputs for the Science Executive Panel on Facility Instruments

As we may have discussed in the past and during the Investigators Working Group meeting in Pasadena, there is the task of showing how each of our instruments contribute to the Global Change grand questions.

Our inputs have to be collected by November 15. As the Chairman of the Facility Instruments Panel for the SEC/TWG I am collecting your efforts and will then deliver them to the appropriate persons in the Program and Project Offices (e.g., Stan Wilson and Gerry Soffen, et al.) In order to standardize our inputs to some extent, I suggest the following:

1. Submit your statements of the five areas or questions in the context of Global Change that your facility instrument will address.
2. Submit the Committee on Earth Sciences (CES) priority chart marked up to show where your instrument makes its contributions. I further suggest that you might indicate the degree of contribution by using the terms: "essential" and "contributing". I would further suggest that you may wish to submit some commentary to more precisely explain the nature of the instrument contribution to the areas in the priorities chart that you feel will be addressed by your instrument. In order to limit the amount of paper that will be accumulated, it is requested that this commentary not exceed two (2) pages in length.
3. Submit a chart showing the products that you are confident can be produced by your instrument to address the questions listed in Number 1 above and the accuracies that will accompany the products. An example of what has been produced for MODIS (very (!) preliminary still) is attached to give you a starting point. Here again, you may wish to submit some commentary (not to exceed 2 pages in total length) to sustain the chart. I would offer my opinion that in both Number 2 and Number 3, the provision of commentary is optional at this point.

Again, I point out that inputs are needed by November 15. The inputs are required at this point in time, in whatever level of completion you can muster, in order to compile material that can be used by Berrien Moore and his Eos Payload Recommendation Panel. That panel will be doing a substantial amount of work in the last part of November. Just send them to my office and I will get them to the Project and Program. My address information is as follows:

Dr. Vincent V. Salomonson  
NASA/GSFC, Code 600  
Building 26, Room 200  
Greenbelt, Maryland 20771

Phone: 301-286-8601 (FTS 888-8601)  
Fax: 301-286-3884  
Telemail: VSALOMONSON or [VSALOMONSON/GSFCMAIL] GSFC/USA

If you have questions or need clarification, please don't hesitate to contact me.

Vincent V. Salomonson  
Chairman, Facility Instruments Panel  
Science Executive Committee  
Eos Investigators Working Group

Fundamental Questions in Earth Science to be addressed by MODIS:

1. Through global observations of ocean color, solar-stimulated fluorescence and thermal emission MODIS will provide greatly improved estimates of phytoplankton biomass, oceanic photosynthetic potential, and sea surface temperature. These will provide improved understanding of the magnitude and variability of oceanic primary production (and the ability of the oceans to sequester carbon), ocean physical variability (related to ocean and ocean-atmosphere heat and mass flux), and the coupling between ocean biological and physical phenomena. MODIS data will lead to better understanding of the transformation of inorganic carbon into organic forms and their eventual burial in deep marine sediments (a key process of the carbon cycle), and the planetary heat and moisture cycles, and how variations in these cycles are affected by, and in turn affect global climate change. MODIS will provide oceanic observations important for addressing oceanic components of global biogeochemical cycles, the hydrologic cycle, and the energy budget of the Earth.

2. Through the acquisition of daily and global observations at spatial resolutions of 214-856 meters, MODIS will provide improved estimates of the areal extent, <sup>seasonal dynamics, and community composition</sup> of major terrestrial biomes, <sup>Global scale</sup> MODIS will assist in the <sup>their internal characteristics and seasonal variability</sup> estimation of photosynthetic potential, biomass, evapotranspiration and net primary productivity within these biomes and will monitor their <sup>vegetation structure</sup> phenology and changes in state. <sup>Through repetitive coverage</sup> MODIS will also <sup>provide regional monitoring of</sup> monitor spatial changes in land cover and land use with particular emphasis on forest alteration, <sup>agricultural expansion</sup> and land degradation in semi-arid environments. Information on the nature and rates of change, including those brought about through anthropogenic activities, will be used to understand their contribution to regional and global climate change. <sup>note I.P. I attached</sup>

- MODIS will play an integral role in monitoring hydrologic processes and fluxes within the major biome types. Improved estimates of soil moisture storage (and storage capacities) and evapotranspiration will become available.

- MODIS will play a key role in biogeochemical cycling of Carbon and Nitrogen through analysis/ monitoring of vegetative growth, senescence, and decomposition processes within the major biome types.

- MODIS will help in studies of the influence of albedo changes on surface surface heating/cooling and associated regional climates, particularly with respect to tendencies toward aridity.

- MODIS will help in quantifying the factors controlling the spatial distribution and biomass of plant communities (topographic, geologic, climatic, and eda, and edaphic factors).

(We propose the following text as replacement for question 2.)

2. Daily acquisition of global MODIS data at spatial resolutions of 214-856 meters will provide estimates of terrestrial leaf area index, absorbed photosynthetically active radiation, surface temperatures and vegetation stress. These direct MODIS products will then be used as inputs to complex biome simulation models, calculating important terrestrial processes such as photosynthesis, evapotranspiration, net primary productivity, and nutrient cycling, which cannot be directly measured by satellites. Weekly compositing of MODIS data and simulations will then allow monitoring effects of climatic perturbations such as drought and human perturbations such as air pollution on growing seasons, and estimating global variability by all biome types. Over annual time scales, areal coverage of global biome types can be mapped, and spatial changes in land cover and land use monitored. Final MODIS products will elucidate the role of terrestrial vegetation in global biogeochemical cycling and feedbacks to climate change.

4. MODIS will provide estimates of the spatial extent of global snow and ice cover along with its temporal variation. Additionally, through measurements of snow and ice extent along with concurrent observations of surface temperature, outgoing longwave radiation, cloud cover and bidirectional reflectance obtained from MODIS, better understanding of the dynamics of snow and ice melt processes over large (greater than several thousands of square kilometers, for example) watersheds, continents and the globe will be derived with subsequent better quantification of the role of these processes in the hydrological cycle.

5. Through observations of marine and continental aerosol properties on a global basis, MODIS will provide information as to the spatial and temporal variability of aerosols and their relationship to sources and sinks associated with natural phenomena (e.g. volcanic activity, aeolian transport, <sup>desert dust transport,</sup> and sea salt) and anthropogenic activity (e.g., biomass and fossil fuel burning). <sup>and temperature,</sup> Measurement of fire size and land cover when combined with ground and airborne measurements will provide regional and global estimates of trace gas emissions from biomass burning. The interaction between aerosols and water vapor will also be studied in the context of cloud evolution.

see note II, p.1  
attached

HK  
YK

DR. LOCKE STUART  
DR. MIKE KING

MODIS

## PROPOSED REVISIONS TO THE MODIS DOCUMENT

### A. Fundamental questions in Earth Science to be addressed by MODIS:

In 3.:

1. The current text is: ....cloud properties including cloud type, temperature, altitude, cloud optical thickness,.....

The suggested text should be (additions are **bold**): ....cloud properties including cloud type, **reflectance**, temperature, altitude, **size distribution**, cloud optical thickness,.....

**I** EXPLANATION: Cloud area and perimeter, or in short "size distribution is one of the MODIS products. It is important in understanding cloud dynamics, and its relation to perturbations such as pollution and global warming. Cloud reflectance in the visible spectrum is used to derive the optical thickness, and so in a way it is not an independent parameter. But since it is directly related to climate, through the reflection of sun light, and since there are still problems in comparison between the optical thickness derived from the measured reflectance, and ground truth, I feel that it should be monitored independently, in order to reveal effects of pollution and climate change on cloud radiative interaction through its reflectance.

2. The word *improved* appears twice (third line from the bottom).

In 5.:

3. The current text is: ....e.g. volcanic activity, aeolean transport, and sea salt)....Measurements of fire size and land cover when.....

The suggested text should be (additions are **bold**): ....e.g. volcanic activity, aeolean transport, **desert dust transport** and sea salt)....Measurements of fire size and temperature, and land cover when.....

**II** EXPLANATION: Desert dust is a major aerosol phenomenon and should be explicitly mentioned, mainly if MODIS emphasize is on semi-dry and desert areas. Fire temperature is very important since for different temperatures of the burning, a different mixture of the trace gases is released. By the way I did not found the word *aeolean* in a dictionary.



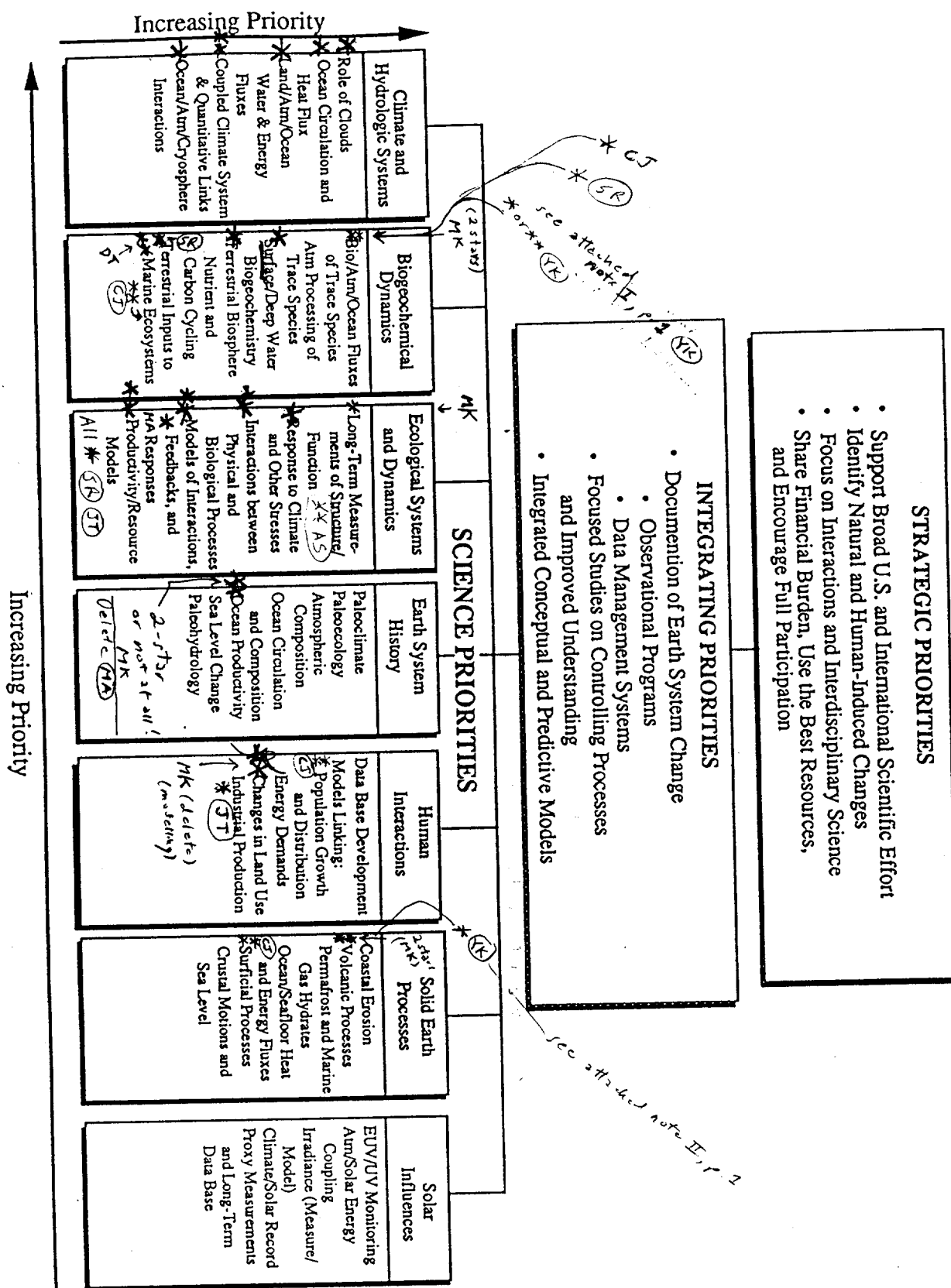


Figure 11. U.S. Global Change Research Program Priority Framework

In Fig. 11:

4. It is suggested to add \* or \*\* to "Bio/Atm/Ocean fluxes of Trace Species".

**EXPLANATION:** Remote sensing of biomass burning that I understand belongs in this category, is responsible for emission of trace gases from the biosphere to the atmosphere. Due to deforestation in South America, and due to increasing rate of savanna burning in Africa and other areas, the input of trace gases to the atmosphere is a growing problem. Except the CO monitoring suggested EOS instrument, MODIS is the only sensor that can be used to monitor fires and an emitted product - aerosol that through the fire temperature is related to the emission of other trace substances.

5. It is suggested to add \* to "Volcanic Processes".

**EXPLANATION:** MODIS can monitor the surface temperature, that can be an early warning of volcanic activity. It can also monitor dust or sulfur aerosol generated in the volcanic activity. These can be used to detect volcanic activity that had happened but was not discovered before, as well as to estimate the magnitude and the characteristics of the activity, and its effect on the atmosphere.

Figure 11. U.S. Global Change Research Program Priority Framework

See MK attached

ROUGH DRAFT SUPPORT COMMENTS FOR CES PRIORITIES CHART (11/1/89)  
(comments solicited from team members. The total writeup cannot exceed two pages. The CES document is being provided for your reference)

## Climate and Hydrologic Systems

MODIS makes essential and strong contributions in this whole general area. In essence MODIS makes contributions through its observations of cloud properties over the globe with relatively high spatial resolution, the extent of the major terrestrial and marine biomes plus the extent of snow and ice. Furthermore it observes state variables such as solar reflectance and thermal emission that relate to radiative processes occurring at the ocean/atmosphere and land/atmosphere interfaces. MODIS will make essential contributions in estimating air/sea flux of energy through sea surface temperature measurements. MODIS also monitors water vapor and aerosol particles that interact to form clouds and therefore determine the cloud characteristics. MODIS makes an essential contribution to the study of clouds through a determination combinations of selected channels in the visible, near, short and long-wave infrared coupled with the 214-856 m spatial resolution and daily coverage. of the global distribution of cloud optical thickness, effective particle radius, cloud top altitude, thermodynamic phase, and areal extent at a resolution of 4Km or better on a daily basis. The observations of ocean color and thermal emission including sea surface temperature contribute to synoptic, large area observations of the patterns of flow dynamics along with providing information pertaining to the latent and sensible heat flux at the ocean atmosphere boundary.

Similarly over land MODIS will monitor the extent (large regions, continental and hemispheric) of hydrologically significant land covers such as vegetation, snow and ice, cloudiness as well as the bi-directional reflectance and surface temperature leading to estimates of key components of the surface radiation balance within various land cover categories. MODIS-T, in combination with MISR, will help to better understand how to make better estimates of albedo using bi-directional observations.

## Biogeochemical Dynamics

The CES document on page 44 clearly refers to the strengths of current observational programs being derived from ocean color remote sensing such as that derived from CZCS and, in the future SeaWiFS. The vegetation index derived from the present AVHRR is also noted. Each of these, of course will be available from MODIS in an improved form. Improved indices will be developed as part of the MODIS program, incorporating the reflectance contribution from soil and surface litter components of the scene. On page 47/CES there is a discussion of Boreal Forest-Atmosphere interaction studies that should be pursued as envisioned for ISLSCP. Here MODIS will contribute

In this area MODIS contributes through its provision of ocean color, sea surface temperature, ocean flows visualization and the mapping of the extent of terrestrial biomes. These then lead to estimates of terrestrial and marine ecosystems productivity.

MODIS, through remote sensing of aerosol emission, fire frequency, size and temperature, will improve the trace gases and particulate emission inventories (CES p. 50) by monitoring biomass burning in tropical forests and savanna regions, as well as aerosol concentrations in industrial regions.

REPLACE:

## Biogeochemical Dynamics

The highest priority in the CES in biogeochemistry is the estimation of global fluxes of carbon between the atmosphere, land and oceans. Subsequent priorities are to understand the role of the terrestrial biosphere in regulating the global carbon and nutrient cycles.

MODIS data on leaf area index, absorbed photosynthetically active radiation, surface temperatures and vegetation stress will contribute directly to this priority by determining global carbon fluxes from photosynthesis, respiration and decomposition for all terrestrial biomes using complex simulation models.

MODIS will be the only sensor with the high temporal/spatial resolutions necessary to follow terrestrial-aquatic transport of materials.

A new para should be added to include MODIS capability for monitoring active fronts of deforestation and the use of HIRIS data (high spatial) in conjunction with MODIS (high temporal / moderate spatial) to give the necessary multi-level data for monitoring tropical deforestation components.

parameterize global  
circulation models  
between terrestrial conditions

MODIS makes essential and strong contributions in this whole general area. In essence MODIS makes contributions through its observations of cloud properties over the globe with relatively high spatial resolution, the extent of the major terrestrial and marine biomes plus the extent of snow and ice. Furthermore it observes state variables such as solar reflectance and thermal emission that relate to radiative processes occurring at the ocean/atmosphere and land/atmosphere interfaces.

MODIS will make essential contributions in estimating air/sea flux of energy through sea surface temperature measurements. MODIS also monitors water vapor and aerosol particles that interact to form clouds and therefore determine the cloud characteristics. (MA)

MODIS makes an essential contribution to the study of clouds through a determination combinations of selected channels in the visible, near, short and long-wave infrared (YK)

with the 214-256 m spatial resolution and daily coverage. of the global distribution of thermodynamic phase, and areal extent (MK)

and angular measurements from MODIS-T and HIRIS (AS)

productivity.

Ecological Systems and Dynamics ← See note II JP attached

The MODIS provides largely contributory information in this general area based on the CES document. On page 56 the vegetation index information is cited but this must be combined with high spatial resolution data such as that from HIRIS and SAR in order to make remote sensing have a fundamental contribution. The contribution from MODIS will come from contributing to the extension of the multi-

high spatial resolution data will help in certain areas of high spatial variability to improve our understanding of the MODIS sensor response. (CS)

MODIS will make essential (MA)

contributions to Long-Term Measurements of Structure/Function. In particular, the long time series of phytoplankton biomass and primary production may be one of the most important legacies of MODIS. In the area of Physical/Biological Interactions, MODIS will also provide essential information for comparisons of biological patterns (both terrestrial and oceanic) with physical forcing. This cannot be done with any other sensor. (AH)

MODIS can monitor both growth and decomposition processes within major biomes. The decomposition component is often regarded as the parameter in studying ecosystem health, function, and degradation. (AH)

## Ecological Systems and Dynamics

The highest priorities of this CES section are to monitor long term changes in vegetation in response to natural and human induced perturbations, increased CO<sub>2</sub>, climate change, physical/chemical stresses, and their interactions. (SR)

MODIS contributes directly to these priorities by daily, global estimation of key terrestrial variables such as leaf area index, APAR, surface temperatures and vegetation stress. (SR)

At annual time scales MODIS is the only sensor that will document changes in global land use/land cover that will influence agro-forestry resource models.

MODIS data will be the preferred input source for complex global biome simulation models, predicting interactions and feedback responses of terrestrial biomes to climatic and other

year data record compiled by the AVHRR on the operational meteorological satellites. The provision of the ocean color and sea surface temperature from MODIS provides an essential element in these studies for mapping ocean primary producer resources. The greater spectral information provided by MODIS relative to AVHRR or CZCS/SeaWiFS should help in elucidating ecosystem properties.

### Earth System History

The long time scales in this general category do not suggest that MODIS will make any significant contributions in this particular except as they are derived in activities that fall under the previous research areas discussed above.

### Human Interactions

<sup>YK</sup> estimating - estimating the total extent of various land use practices associated with anthropogenic activities. Among these are such things as deforestation, extent of agricultural practices, <sup>W3</sup> urbanization, etc. The MODIS estimates must be refined through the use of high spatial resolution data to depict the fine detail and processes occurring at the boundaries and where there may be mixtures of land use within MODIS pixels. As noted in the MODIS questions, MODIS will be most applicable in areas with lesser cloudiness e.g., semi-arid and arid areas. <sup>YK</sup>

JT  
(Delete)

### Solid Earth Processes

MODIS will contribute to this area through mapping the extent of permafrost and large glaciers or ice sheets. It will also serve a role as an early detection mechanism for volcanic eruptions in remote areas (i.e., the high temperature bands on MODIS-N are there, at least in part, to provide this capability.

### Solar Influences

MODIS makes only very minor, if any, contributions in this area.

JT

The comments under the heading 'human interactions' with reference to semi-arid areas and cloudiness is unhelpful: the problems of cloudiness refer to every optical sensor and it is the high 'temporal resolution' of MODIS which makes it such a key sensor for more cloudy areas.

To: LSTUART  
Subj: IWG Input

JP  
John Parslow

Locke:

Herewith my response to the IWG input.

1. The fundamental questions and priority framework seem ok.
2. The support comments seem a little general and vague. I've written a couple of paragraphs for the Biogeochemical Dynamics, and Ecological Systems and Dynamics sections. I don't expect you to adopt them verbatim of course, but you may find the odd phrase or idea useful.

#### Biogeochemical Dynamics.

The CES document (P44) refers to the remote sensing of ocean color from CZCS and vegetation index from NOAA as current observational strengths. In fact, there is no current ocean color satellite, and observation in the early 1990's depends on the launch of SEAWIFS. MODIS will allow much improved estimates of ocean color, and other important parameters such as attenuation coefficients, dissolved organics, etc, especially in shelf areas which are important sites of carbon burial in sediment. ~~MODIS will also allow mapping of terrestrial biomes, and their structural and functional properties, at improved spatial resolution.~~

The estimation of fluxes, as opposed to standing stocks, is essential to biogeochemical dynamics. MODIS will permit improved estimates of marine and terrestrial production, by providing measurements of physiological indicators, such as chlorophyll fluorescence in the oceans, and driving variables such as surface illumination and surface temperature. MODIS estimates of aerosols may also be significant, given current theories of limitation of marine primary production by aeolian trace metals.

#### Ecological Systems and Dynamics.

The CES document suggests three components to this area: characterization, measurement and monitoring; research on ecological processes; development of predictive models. MODIS allows global monitoring of terrestrial and marine ecosystems at coarse spatial but fine temporal resolution. It provides frequent estimates of coarse biomass measures such as ocean color and NDVI, and more specific information such as coccolith or blue-green algal abundance in the oceans. MODIS also contributes to research on ecological processes by providing data on physical driving variables (solar illumination, temperature, cloud cover) on short time scales. Ecological processes cover a large range of space and time scales, and MODIS fills an important slot in this spectrum.

King 3

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CES document is being provided for your reference)

### Climate and Hydrologic Systems

MODIS makes essential and strong contributions in this whole general area. In essence MODIS makes contributions through its observations of cloud properties over the globe with relatively high spatial resolution, the extent of the major terrestrial and marine biomes plus the extent of snow and ice. Furthermore it observes state variables such as solar reflectance and thermal emission that relate to radiative processes occurring at the ocean/atmosphere and land/atmosphere interfaces.

of the global distribution of the  
MODIS makes an essential contribution to the study of clouds through a determination of combinations of selected channels in the visible, near, short and long-wave infrared coupled with the 214-856 m spatial resolution and daily coverage. of the cloud optical thickness, effective particle radius, cloud top altitude, thermodynamic phase and areal extent at a resolution of 4 km or better on a daily basis. The observations of ocean color and thermal emission including sea surface temperature contribute to synoptic, large area observations of the patterns of flow dynamics along with providing information pertaining to the latent and sensible heat flux at the ocean atmosphere boundary.

Similarly over land MODIS will monitor the extent (large regions, continental and hemispheric) of hydrologically significant land covers such as vegetation, snow and ice, cloudiness as well as the bi-directional reflectance and surface temperature leading to estimates of key components of the surface radiation balance within various land cover categories. MODIS-T, in combination with MISR, will help to better understand how to make better estimates of albedo using bi-directional reflectance observations.

Kaufman's comment → Biogeochemical Dynamics

The CES document on page 44 clearly refers to the strengths of current observational programs being derived from ocean color remote sensing such as that derived from CZCS and, in the future SeaWiFS. The vegetation index derived from the present AVHRR is also noted. Each of these, of course will be available produced from MODIS, but with improved accuracy and improved sampling.

newide X On page 47/CES there is a discussion of Boreal Forest-Atmosphere interaction studies that should be pursued as envisioned for ISLSCP. Here MODIS will contribute

In this area MODIS contributes through its provision of ocean color, sea surface temperature, ocean flows visualization and the mapping of the extent of terrestrial biomes. These then lead to estimates of terrestrial and marine ecosystems productivity. to understand biogeochemical dynamics through concentration

Kaufman > Ecological Systems and Dynamics

The MODIS provides largely contributory information in this general area based on the CES document. On page 56 the vegetation index information is cited but this must be combined with high spatial resolution data such as that from HIRIS and SAR in order to make remote sensing have a fundamental contribution. The contribution from MODIS will come from contributing to the extension of the multi-

year data record compiled by the AVHRR on the operational meteorological satellites. The provision of the ocean color and sea surface temperature from MODIS provides an essential element in these studies for mapping ocean primary producer resources. The greater spectral information provided by MODIS relative to AVHRR or CZCS/SeaWiFS should help in elucidating ecosystem properties.

### Earth System History

The long time scales in this general category do not suggest that MODIS <sup>or any other Eos sensor</sup> will ~~make~~ be able to any significant contributions ~~in this particular~~ except as they are derived in activities that fall under the previous research areas discussed above.

### Human Interactions

MODIS <sup>9</sup> makes a strong contribution in this area by offering a direct approach to estimating the total extent of various land use practices associated with anthropogenic activities. Among these are such things as deforestation, extent of agricultural practices, urbanization, etc. The MODIS estimates must be refined through the use of high spatial resolution data to depict the fine detail and processes occurring at the boundaries and where there may be mixtures of land use within MODIS pixels. As noted in the MODIS questions, MODIS will be most applicable in areas with lesser cloudiness e.g., semi-arid and arid areas. MODIS will provide data to help validate models.

### Solid Earth Processes

MODIS will contribute to this area through mapping the extent of permafrost and large glaciers or ice sheets. It will also serve a role as an early detection mechanism for volcanic eruptions in remote areas (i.e., the high temperature bands on MODIS-N are there, at least in part, to provide this capability).

### Solar Influences

MODIS makes only very minor, if any, contributions in this area.

MODIS will also make it possible to study variations in vegetation <sup>arising from</sup> ~~of man-made~~ (Amazon forest burning, grazing in arid regions) and natural (El Niño drought) stresses on ecological systems.



Local experiment accuracies cannot be generalized to global accuracy. 1/30/89

DISCUSS AT NEXT TECHNICAL MEETING! (CJ)

PRELIMINARY ESTIMATES OF MODIS CORE DATA PRODUCT ACCURACIES, AND THEIR RELEVANCE TO KEY EARTH SCIENCE ISSUES	SCIENCE QUESTION ADDRESSED						ESTIMATED ACCURACY OF MODIS CORE DATA PRODUCT	
- ATMOSPHERE CORE DATA PRODUCT ANALYSES	1	2	3	4	5	6	PRESENT-DAY	MODIS-ERA
1. <u>Total Column Ozone</u>	I					I	$\pm 5$ to $10\%$ <sup>0.2 <math>\mu</math>m (YK)</sup>	$\pm 5$ to $10\%$ <sup>0.1 <math>\mu</math>m (YK)</sup>
2. <u>Aerosol Optical Depth</u>	I	I				D	$\pm 0.05$	$\pm 0.05$
3. <u>Aerosol Size Distribution</u>	I	I				D	$\pm 10\%$	$\pm 10\%$
4. <u>Aerosol Mass Loading</u>	I	I				D	$\pm 40\%$	$\pm 30\%$
5. <u>Aerosol Single Scattering Albedo</u>	I	I				D	$\pm 0.04$	$\pm 0.04$
6. <u>Lifted Index</u>			D				$\pm 3^\circ\text{C}$	$\pm 3^\circ\text{C}$
7. <u>Temperature and Moisture Profiles</u>			I		I		$\pm 2^\circ\text{C}$	$\pm 1^\circ\text{C}$
8. <u>Total Precipitable Water</u>					D		$\pm 30\%$	$\pm 15\% \pm 5\%$ (YK)
9. <u>Cloud Fractional Area</u>	D		D	D			$\pm 10\%$ absol.	$\pm 10\%$ absol.
10. <u>Cloud Area and Perimeter</u>			D				$\pm$	$\pm$
11. <u>Cloud Optical Thickness</u>	D		D	D			$\pm 50\%$ absol.	$\pm 20\%$ absol.
12. <u>Cloud Effective Emissivity</u>			D	D			$\pm 20\%$ absol.	$\pm 20\%$ absol.
13. <u>Cloud Top Pressure</u>			D				$\pm 25$ to $50\text{mb}$	$\pm 25$ to $50\text{mb}$
14. <u>Cloud Top Temperature</u>			D				$\pm 2^\circ\text{C}$	$\pm 1^\circ\text{C}$
15. <u>Cloud Water Thermodynamic Phase</u>			D				N/A	Possible
16. <u>Cloud Droplet Effective Radius</u>			D				$\pm 10\%$	$\pm 10\%$
I. LAND CORE DATA PRODUCT ANALYSES	1	2	3	4	5	6	PRESENT-DAY	MODIS-ERA
A. <u>Vegetation Indices</u>		D			D		$\pm 0.1$ <sup>(XG)</sup>	$\pm 0.04$ <sup>(XG)</sup>
B. <u>Surface Temperature</u>		D		D	D		$\pm 10^\circ\text{C}$ <sup><math>\pm 3</math> to <math>\pm 6^\circ\text{C}</math></sup>	$\pm 2^\circ\text{C}$ <sup><math>\pm 1^\circ</math> to <math>\pm 2^\circ\text{C}</math></sup>
C. <u>Thermal Anomalies</u>		D			D		$\pm 50^\circ\text{C}$	$\pm 5^\circ\text{C}$
D. <u>Spectral Surface Albedo</u>				D	D		$\pm 0.01$	$\pm 0.01$
E. <u>Snowcover</u>				D			N/A	N/A
F. <u>Level-2 Land-Leaving Radiances</u>		I		I	I		$\pm 20\%$	$\pm 10\%$
G. <u>Level-1 Topographic Corrections</u>		I		I	I		$\pm 1\text{km}$	$100\text{m}$
H. <u>Surface Water Cover Mapping</u>					D		N/A	N/A
I. <u>Biome Type</u>		D					N/A	N/A
J. <u>Primary Production</u>		D					$r^2 = 0.5$ to $0.8$	
K. <u>Incident PAR</u>		D					?	$\pm 20\%$
L. <u>Broad Soil Types</u>		D					N/A	N/A
M. <u>Thermal Inertia</u> (?)		D					?	N/A
N. <u>Land Moisture Regimes</u> (?)		D					N/A	N/A
O. <u>Land Thermal Regimes</u> (?)		D					N/A	N/A
P. <u>Evapotranspiration</u> (?)								
Active Radiation	D						$\pm 40\%$	$\pm 25\%$
I. <u>Attenuation at 490nm</u> (Case I) (JP)	D						$\pm 35\%$ <sup><math>R^2 = 0.9</math></sup>	$\pm 20\% \pm 35\%$ (HG)
J. <u>Attenuation of Photosynthetically Active Radiation</u>	D						N/A	$\pm 20\%$
K. <u>Primary Productivity</u>	D						$R^2 = 0.30$ <sup>not meaningful</sup>	$\pm ?$ (JP)
L. <u>Angstrom Exponent</u>	I				D		$\pm 10\%$	$\pm 6\% \pm 10\%$ (HG)
M. <u>Single Scattering Aerosol Radiation</u>	I				D			
N. <u>In-situ Validation Observations</u>	I	I					Instr. Dep.	Instr. Dep.

Notes: "D" indicates that a science question/issue is directly addressed.  
"I" indicates that a science question/issue is indirectly addressed.

1. Dissolved Organic Material (Concentration) D N/A  $\pm 150\%$  FH  
2. Phycocyanin Pigment Concentration D N/A  $\pm 200\%$  FH

see III M (below), same product, different accuracy? (YT)

higher accuracy in situ, lower accuracy general (WZ)

(SP)

AH

see "

see note II, p. 2 (HG)

150/89

ACCURACIES

DISCUSS AT NEXT TECHNICAL MEETING! (CJ)

PRELIMINARY ESTIMATES OF MODIS CORE DATA PRODUCT ACCURACIES, AND THEIR RELEVANCE TO KEY EARTH SCIENCE ISSUES	SCIENCE QUESTION ADDRESSED						ESTIMATED ACCURACY OF MODIS CORE DATA PRODUCT	
-ATMOSPHERE CORE DATA PRODUCT ANALYSES	1	2	3	4	5	6	PRESENT-DAY	MODIS-ERA
Total Column Ozone	I					I	$\pm 5$ to $10\%$ $\text{YK}$	$\pm 5$ to $10\%$ $\text{YK}$
Aerosol Optical Depth	I	I				D	$\pm 0.05$	$\pm 0.05$
Aerosol Size Distribution	I	I				D	$\pm 10\%$	$\pm 10\%$
Aerosol Mass Loading	I	I				D	$\pm 40\%$	$\pm 30\%$
Aerosol Single Scattering Albedo	I	I				D	$\pm 0.04$	$\pm 0.04$
Lifted Index				D			$\pm 3^\circ\text{C}$	$\pm 3^\circ\text{C}$
Temperature and Moisture Profiles				I		I	$\pm 2^\circ\text{C}$	$\pm 1^\circ\text{C}$
Total Precipitable Water						D	$\pm 30\%$	$\pm 15\% \pm 5\% \text{YK}$
Cloud Fractional Area		D	D	D			$\pm 10\%$ absol.	$\pm 10\%$ absol.
Cloud Area and Perimeter				D			$\pm$	$\pm$
Cloud Optical Thickness		D	D	D			$\pm 50\%$ absol.	$\pm 20\%$ absol.
Cloud Effective Emissivity			D	D			$\pm 20\%$ absol.	$\pm 20\%$ absol.
Cloud Top Pressure				D			$\pm 25$ to $50\text{mb}$	$\pm 25$ to $50\text{mb}$
Cloud Top Temperature				D			$\pm 2^\circ\text{C}$	$\pm 1^\circ\text{C}$
Cloud Water Thermodynamic Phase				D			N/A	N/A

see III M (below). Same product, different accuracy? (CJ)

VSalomonsen/gsfcmail, WBarnes/gsfcmail,  
[H.GORDON/OMNET] MAIL/USA, [K.CARDER/OMNET] MAIL/USA,  
[M.ABBOTT/OMNET] MAIL/USA, [O.BROWN/OMNET] MAIL/USA,  
[R.EVANS/OMNET] MAIL/USA, [W.ESAIAS/OMNET] MAIL/USA

Subj: MODIS-N

H.R. Gordon's Comments Re the latest MODIS-N C/D

Table 3.3.3 IFOV's and Spectral Band Characteristics:

III. OCEAN CORE DATA PRODUCT ANALYSES	1	2	3	4	5	6	PRESENT-DAY	MODIS-ERA
A. Sea Surface Temperatures	D		D	D			$\pm 0.6\text{K}$	$\pm 0.3\text{K}$
B. Sea Ice	I			D			Yes, if $25\%$	Yes, if $25\%$
C. Water Leaving Radiance	D						$\pm 10\%$ ? (JP)	$\pm 7\% \pm 10\% \text{HG}$
D. Chlorophyll Fluorescence	D						N/A	$\pm 50$ to $100\%$ $\pm 30 \text{MA}$
E. Chlorophyll-A Pigment Concentration	D						$\pm 35\%$	$\pm 20\% \pm 35\% \text{HG}$
F. Case-II Waters Chlorophyll-A Pigment Concentration - Carder, Hope	D						$300\%$	$\pm 50\%$ ? (JP)
G. Detached Coccolith Concentration	D						N/A	$\pm 35\%$ - see note IV, P.1 (HG)
H. Surface Incident Photosynthetically Active Radiation	D						$\pm 40\%$	$\pm 25\%$
I. Attenuation at $490\text{nm}$ (Case I) (JP)	D						$\pm 35\%$ ; $R^2 = 0.9$	$\pm 20\% \pm 35\% \text{HG}$
J. Attenuation of Photosynthetically Active Radiation	D						N/A $300\%$ (JP)	$\pm 20\%$
K. Primary Productivity	D						$R^2 = 0.30$ not meaningful (JP)	$\pm ?$ (JP)
L. Angstrom Exponent	I					D	$\pm 10\%$	$\pm 6\% \pm 10\% \text{HG}$
M. Single Scattering Aerosol Radiation	I					D	Instr. Dep.	Instr. Dep.
N. In-situ Validation Observations	I		I					

"OK for typical" (JP)  
see note I, P.1 Addenda (JP)  
see note II, P.1 (HG)  
see note III, P.1 (HG)  
see note IV, P.1 (HG)  
see note I, P.2 (HG)  
see note II, P.2 (HG)

Notes: "D" indicates that a science question/issue is directly addressed.  
"I" indicates that a science question/issue is indirectly addressed.

O. ~~G. Gordon~~ Dissolved Organic Material (JP) D N/A  $\pm 150\%$  FH  
P. Phycoerythrin Pigment Concentration (JP) D N/A  $\pm 200\%$  FH

Purged.

Action?

Posted: Fri Nov 10, 1989 2:04 PM EST                      Msg: IGIJ-4090-8243/08  
From: [H.GORDON/OMNET] MAIL/USA  
To: BGuenther/gsfcmail, JBarker/gsfcmail, LSTUART/gsfcmail,  
PSlater/gsfcmail,  
VSalomonsen/gsfcmail, WBarnes/gsfcmail,  
[H.GORDON/OMNET] MAIL/USA, [K.CARDER/OMNET] MAIL/USA,  
[M.ABBOTT/OMNET] MAIL/USA, [O.BROWN/OMNET] MAIL/USA,  
[R.EVANS/OMNET] MAIL/USA, [W.ESAIAS/OMNET] MAIL/USA  
Subj: MODIS Accuracy Estimates

In reference to the table specifying the accuracies of various products (in the package that was sent to the Modis Team) and in the interest of accuracy, I have a few comments concerning the ocean data products.

C. Water Leaving Radiance: Under good conditions, relatively clear atmosphere, nearby clear water pixels on which to base the atmospheric correction and at pigment concentrations of  $\sim 0.5 \text{ mg/m}^3$  or less, we achieved an accuracy of  $\pm 10\%$  with CZCS; however, in the general situation the error is larger. Thus, for CZCS an accuracy of  $\pm 10\%$  under OPTIMUM conditions was demonstrated. For MODIS (and SeaWiFS) the addition of the bands at 745 and 865 nm removes restrictions that were present with CZCS, i.e., no clear water areas are required, etc. My goal for MODIS and SeaWiFS (and I expect to be able to achieve it) is an accuracy of  $\pm 10\%$  (or perhaps some what better) under TYPICAL conditions when the pigment concentrations is  $\sim 0.5 \text{ mg/m}^3$  or less. Thus the real improvement is from  $\pm 10\%$  under OPTIMUM conditions to  $\pm 10\%$  under TYPICAL conditions.

D. Chlorophyll-a Fluorescence: I don't know where this number came from or what it means. Is it the error in the water-leaving radiance resulting from fluorescence? Is it the error in something derived from fluorescence? If the fluorescence is weak, say at a chlorophyll concentration of  $0.1 \text{ mg/m}^3$ , the error in the measurement of the fluorescence radiance may be very much larger than that given, and at high concentrations it might be less.

E. Chlorophyll-a Pigment Concentration: The comments I made in reference to water-leaving radiance (C) above apply equally well here. The key is replacing OPTIMUM conditions with TYPICAL conditions. In fact the error in the pigment concentration algorithm for in Case 1 waters using SHIP data is  $\sim \pm 20\%$  so the accuracy in the table is approximately that which we think is possible from ships, i.e., it implies a PERFECT atmospheric correction and NO sensor noise.

G. Detached Coccolith Concentration: I don't know where an accuracy of  $\pm 35\%$  came from. We have not made a good assessment yet; however, the accuracy becomes better the higher the concentration of coccoliths. I have no real objection to the 35% figure, I just don't really know what it should be.

I. Attenuation at 490 nm: Same comment here as for (C) and (E).

L. Angstrom Exponent: I don't have a number that I can go to the wall for, but based on the CZCS experience, I expect +/- 15% is reasonable for the exponent between 745 and 865 nm for TYPICAL scenes over the ocean. The more turbid the atmosphere, the higher the accuracy. Conversely, for very clear atmospheres the error will be larger.

M. Single Scattering Aerosol Radiance: This was never determined routinely for CZCS; however, we expect to start with the existing data base in the near future. What was determined for CZCS was the actual aerosol radiance at 670 nm. An accuracy of +/- 10% is reasonable at this wavelength for Case 1 waters with pigments < about 0.5-1. mg/m<sup>3</sup>.

Action? purge

Purged.

Action?

Command? check gsfcmail

Now using bulletin board.

Command? scan

Bulletin Board contains:

No. Lines	Delivered	From	Subject
1 206	Nov 10 14:11	CUST.SVC	NICKNAMES is here !!!
2 7	Nov 8 16:15	WMACOUGHTRY	Urgent "MANIFEST" Bulletin Board
3 2	Nov 9 13:04	ANEGRI	post office closed
4 27	Nov 13 8:13	REMARTIN	MISSING EQUIPMENT -- HP-8780A DE
5 26	Nov 13 11:57	FGORDON	SMM STATUS

Command? read

Posted: Fri Nov 10, 1989 2:11 PM EST  
From: CUST.SVC  
To: GSFCMAIL (URG)  
CC:  
Subj: NICKNAMES is here !!!

Msg: PJIJ-1622-4531

USE OF NICKNAMES

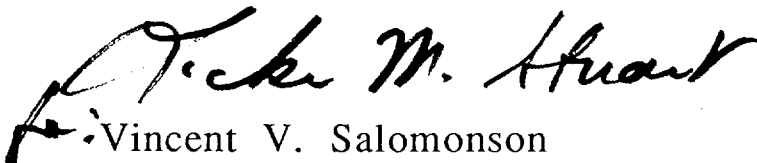
2 November, 1989

To: MODIS Team Members  
From: V. V. Salomonson  
Subject: MODIS-N Specifications

Attached are Sections 3.3 and 3.4 of the MODIS-N specifications. Any comments that you have submitted have been carefully considered and wherever possible incorporated into these specifications. The specifications are to be approved by myself and others by November 15. I am providing these few pages so that you have one last (!! ) opportunity to check the specifications before they are issued. It is my opinion that the specifications have gone as far as they can go in providing a MODIS-N instrument that is responsive to the scientific community and is still within cost, schedule, etc. Parenthetically I must comment that MODIS-N is sufficiently prominent in the Eos scheme of things to be addressed specifically by the OMB, because it is the pacing instrument in the overall Eos schedule.

**PLEASE REVIEW THIS INFORMATION CONFIDENTIALLY AND DISCRETELY. IT SHOULD NOT BE DISCUSSED WITH ANYONE THAT MAY RELAY THE INFORMATION TO A POTENTIAL BIDDER ON THE MODIS-N CONTRACT. JUST SEND ANY FINAL, LAST-MINUTE THOUGHTS YOU MIGHT HAVE TO LOCKE STUART, OR ALTERNATIVELY BILL BARNES OR ME USING THE USUAL MEANS OF COMMUNICATION.**

Thanks for your many efforts.

  
Vincent V. Salomonson  
MODIS Team Leader

### 3.3 OPTICAL REQUIREMENTS

#### 3.3.1 Instantaneous Field of View (IFOV)

The along-track IFOV at nadir of the various bands shall be as given in Table 3.3.3. The IFOV is defined as the projection of the detector or field-stop onto the Earth at nadir, and excludes diffraction effects and optical aberrations. The tolerance on the mean along-track and cross-track IFOV for any band is  $\pm 3\%$ . The cross-track IFOV may be equal to or less than the along-track IFOV, depending upon signal/noise and MTF considerations. Each detector within a band shall have an IFOV that does not differ from the mean by more than  $\pm 5\%$  in either dimension. Sampling shall be once per nominal (square) IFOV.

#### 3.3.2 Field of View

The instrument shall scan the IFOV  $\pm 55$  degrees cross-track about nadir, using a scanner which does not introduce image rotation.

Table 3.3.3: IFOV's and Spectral Band Characteristics

BAND	CENTER WAVELENGTH (nm)	IFOV (m)	BANDWIDTH (nm)
1	659±5	214	50
2	865±5	214	40
3	470±5	428	20
4	555±5	428	20
5	1240±6	428	20
6	1640±8	428	20
(YK) stat <del>7</del>	<del>2060±10</del>	<del>428</del>	<del>50</del> delete
8	2131±10	428	50
9	415±2	856	15
10	443±1	856	10
11	490±1	856	10
12	531±2	856	10
13	565±5	856	10
14	653±1, -2	856	15
15	681±1	856	10
16	745±2 ← See comment (HG)	856	10
17	865±5	856	15
18	908±1 905 (YK)	856	35 30 (YK) see attached
19	936±1	856	10
20	950±1 940 (YK)	856	20 50 (YK)
21	3750±19	856	180
22	3959±20	856	50
23	4050±20	856	50
24	4465±22	856	50
25	4515±22	856	50
26	4565±23	856	50
27	6715±34	856	360
28	7325±37	856	300
29	8550±43	856	300
30	9730±49	856	200
31	11030±55	856	500
32	12020±60	856	500
33	13335±67	856	300
34	13635±68	856	300
35	13935±70	856	300
36	14235±71	856	300

I am a little concerned about the change in the 750 nm band to 745 nm. From some old figures I have there is a water vapor absorption band that seems to extend from about 715 nm to 740 nm. If the 745 nm band shifts at all to shorter wavelengths it will shift into the water band. There is also an Oxygen band that starts at 759 nm and extends to about 770 nm. If the band is at 750 nm it can shift by +/- 4 nm without getting into the water or the Oxygen bands. If it moves into the Oxygen band, we should be able to correct for the Oxygen absorption; however, if it moves into the water vapor band I do not know if we will have enough information to perform a correction for the water absorption. Although I expect this has been looked at in detail by others already, I would be happier if Mike King would look at some better spectra of water vapor and see if the 750 nm to 745 nm shift is a much of a problem as I think it might be. I must point out that this band is VERY important to ocean studies since it will be the key band for atmospheric correction. I would hate to see an error here slip through the cracks at this late date.

## Modis water vapor and fire channels

### 1. Water vapor in cloud free atmosphere

A sensitivity study is being conducted for the optimization of MODIS bands 18 and 20. Though the study was not finished as yet, present results show that there should be an advantage making the following changes:

channel #	old wavelengths (nm)		new wavelengths (nm)	
	center	bandwidth	center	bandwidth
18	908	35	905	30
20	950	20	940	50

I The present setting generates 2 channels, one with medium water absorption (18) and second with strong water absorption (20), in addition to band 19 that has maximal water vapor absorption in the near IR. The remote sensing procedure will be based (as presently conceived) on ratio of 2 channels, a non-absorbing channel (band 2) and an absorbing channel (band 18, 19 or 20). In most cases of remote sensing of water vapor in cloud free atmosphere the ratio of band 2 to band 20 will be used. For very dry conditions the ratio of band 2 to band 19 will be used, and for very wet conditions the ratio of band 2 to band 18 will be used. The provision of 3 water vapor channels with substantially different absorption strength, will also provide the opportunity for correlation methods to be developed, in a similar line to the methods proposed for HIRIS. The wider channel 20 will make it less sensitive to uncertainties in the spectral band.

### 2. Detection of fires

Since the 2.06 channel was canceled and it was not found useful to generate a new cloud channel, it is proposed to form a special fire channel. As a result the 2.06 channel is proposed to move to  $3.75\mu\text{m}$  with width of 50 nm. The channel should not saturate under  $700^\circ\text{K}$  and have a step of at most  $5^\circ\text{K}$ .



### 3.3.3.1 Definitions

These parameters relate to performance of the complete instrument system. See Figure 3.3.3.1.

- a. Band Edge - The wavelength at which the response is half of the peak response; there is a lower and an upper band edge.
- b. Center Wavelength - The wavelength midway between the band edges.
- c. Bandpass (or bandwidth) - The wavelength interval between the lower and upper band edges. This is also referred to as the FWHM response.
- d. One-percent Response Point - the wavelength, nearest to the center wavelength, at which the response is one-percent of the peak response; there is an lower and an upper one-percent response point.
- e. Extended Bandpass - The wavelength interval between the lower and upper one-percent response points.
- f. Out-of-Band Response Regions - The spectral regions beyond the extended bandpass.
- g. Out-of-Band Response - The ratio of integrated out-of-band spectral response to integrated extended bandpass spectral response. This ratio includes both the upper and lower wings of the response.
- h. Out-of-Band Blocking - The inverse of the ratio defined as the out-of-band response.
- i. Edge Range - The wavelength interval, in nanometers, between 5% of peak response and 80% of peak response.

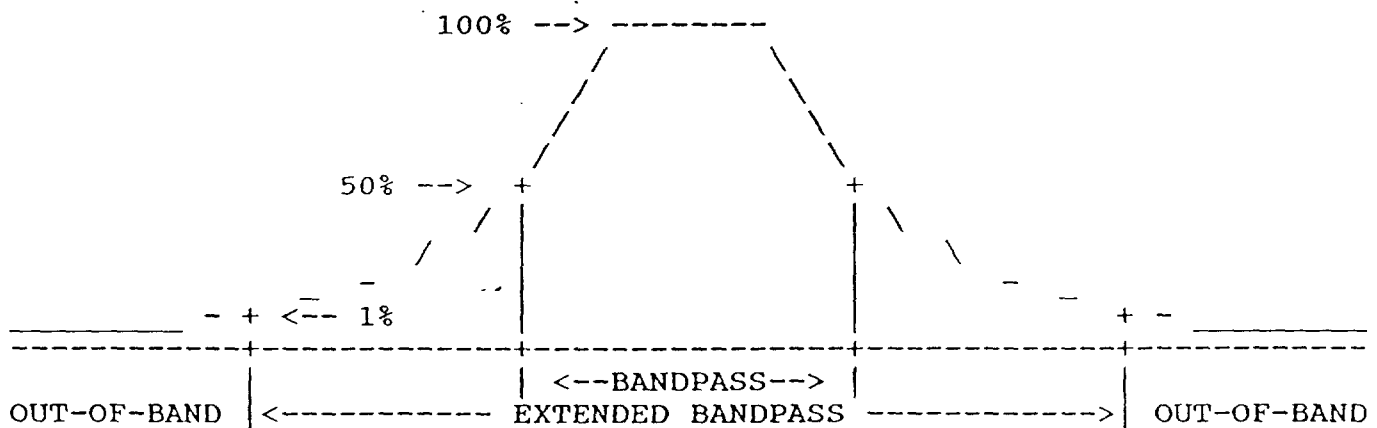


FIGURE 3.3.3.1

### 3.3.3.2 Wavelength Tolerances

*See table 3.3.3*

The system center wavelengths shall be within  $\pm 0.5\%$  ( $\pm 0.25\%$  for bands 9 to 17) of the values tabulated in Table 3.3.3.

The system bandwidth tolerance shall be  $\pm 0.5\%$  ( $\pm 0.25\%$  for bands 9 to 17) of the corresponding center wavelength tabulated in Table 3.3.3.

The edge range shall not exceed 50% of the bandwidth in any band.

### 3.3.3.3 Out-of-Band Characteristics

The out-of-band response shall be less than 5% (three-sigma). Each one-percent response point shall be within 1.5 times the bandpass from the corresponding band edge. Compliance with this specification shall be determined for a source spectrum equivalent to the sum of Lcloud plus an extended 300K blackbody.

Lcloud is defined as the spectral radiance of a Lambertian surface of 100% reflectance, illuminated by the sun at a zenith angle of 22.5 degrees. It is given in Table 3.3.4.1 for the VIS, NIR, and SWIR bands, and may be calculated for the thermal bands.

### 3.3.3.4 Ripple

The response between the 80% of peak points of the bandpass shall always exceed 80% of the peak response.

### 3.3.4 Sensitivity Requirements

The sensitivity requirements for the MODIS-N bands are given here. If the contractor determines that time delay and integration (TDI) is required for any band, this processing shall be done on board the instrument to minimize the data rate, unless otherwise negotiated.

The instrument shall be capable of measuring spectral radiances from the NEdL up to  $L_{max}$ . The instrument SNR shall be measured over this range of radiances.

#### 3.3.4.1 Visible, Near IR and Short Wave IR Bands

Table 3.3.4.1 applies to the VIS, NIR and SWIR bands. It presents the requirements for Noise Equivalent Differential Spectral Radiance, NEdL, and for Signal-to-Noise Ratio, SNR. It also presents the maximum spectral radiance at the entrance aperture of the instrument,  $L_{max}$ , calculated for the expected maximum values of Earth surface reflectance plus atmospheric effects, for a solar zenith angle of 22.5 degrees. Additionally, the table contains the typical spectral radiance,  $L_{typical}$ , at the instrument entrance aperture, for a solar zenith angle of 70 degrees. The required NEdL and SNR shall be achieved for  $L_{typical}$ . The SNR is the ratio of  $L_{typical}$  to the required NEdL.

### 3.3.4.2 Thermal Emittance Bands

Table 3.3.4.2 presents requirements for the thermal emittance (MWIR and LWIR) bands. The table shows required Noise Equivalent Differential Temperature (NEdT) and NEdL for typical scene temperatures and spectral radiances,  $L_{\text{typical}}$ , of extended scenes. The table also gives the maximum scene temperatures,  $T_{\text{max}}$ , and equivalent maximum spectral radiance values,  $L_{\text{max}}$ , which the instrument shall measure. The NEdT shall be met at the typical scene temperatures.

Table 3.3.4.2  
MODIS-N Thermal Bands

BAND	CENTER WAVELENGTH (nm)	TYPICAL SCENE TEMP $T_{\text{typical}}$ (K)	TYPICAL SPECTRAL RADIANCE $L_{\text{typical}}$ (*)	REQ'D NEdT (K)	NEdL (*)	MAX SCENE TEMP $T_{\text{max}}$ (K)	MAX SPECTRAL RADIANCE $L_{\text{max}}$ (*)
21	3750	300	0.45	0.05	0.000957	335	1.71
7→21-hi	3750	700	671	5.1.00	5.28	700	671
22	3959	300	0.67	0.07	0.00190	328	1.89
23	4050	300	0.79	0.07	0.00217	328	2.16
24	4465	250	0.17	0.25	0.00218	264	0.34
25	4515	275	0.59	0.25	0.00620	285	0.88
26	4565	275	0.63	0.25	0.00659	302	1.76
27	6715	240	1.16	0.25	0.0108	271	3.21
28	7325	250	2.18	0.25	0.0172	275	4.46
29	8550	300	9.58	0.05	0.00899	324	14.54
29-hi	8550	400	39.38	1.00	0.421	400	39.38
30	9730	250	3.69	0.25	0.0219	275	6.34
31	11030	300	9.55	0.05	0.00701	324	13.25
31-hi	11030	400	29.1	1.00	0.247	400	29.08
32	12020	300	8.94	0.05	0.00606	324	12.10
32-hi	12020	400	25.1	1.00	0.198	400	25.07
33	13335	260	4.52	0.25	0.0183	285	6.56
34	13635	250	3.76	0.25	0.0161	268	5.02
35	13935	240	3.11	0.25	0.0141	261	4.42
36	14235	220	2.08	0.35	0.0154	238	2.96

\* = Watts/m<sup>2</sup>/um/sr

- Notes: 1) The high range of nonlinear band 21 is 335K to 700K.  
 2) The high range of nonlinear bands 29, 35 & 36 is 324K to 400K.  
~~3) The NEdT within these high ranges shall be less than 1.0K.~~  
 4) The NEdL shown for each -hi band applies at  $T_{\text{max}}$ .

### 3.3.5 Instrument Polarization Insensitivity

All MODIS-N bands shall be insensitive to linear polarization as defined here. An analytical end-to-end polarization model shall be provided as part of the radiometric math model.

The polarization factor, as defined below, shall be no greater than 0.02 over scan angles of +/-45 degrees and wavelengths from 0.43 to 2.2um.

$$PF = (I_{max} - I_{min}) / (I_{max} + I_{min}) < 0.02$$

The contractor shall map the magnitude and direction of the polarization sensitivity of all bands over the full range of scan angles. This mapping may combine measurements for at least sixteen representative bands, including bands 9 through 17, with interpolation for the other bands. The polarization model shall be adjusted to account for these data.

### 3.4 SYSTEM PERFORMANCE REQUIREMENTS

All performance and ground calibration data shall be analyzed and displayed in real time and in an quickly understood form. This form shall generally be plots in engineering units.

#### 3.4.1 Dynamic Range

MODIS-N shall be designed to operate over a dynamic range that extends from the noise floor (NE<sub>DL</sub>) in each band to the maximum levels (L<sub>max</sub>) given in Tables 3.3.4.1 and 3.3.4.2.

#### 3.4.2 Modulation Transfer Function

The Modulation Transfer Function (MTF) of the instrument system shall satisfy or exceed the values tabulated below. This MTF shall apply to both along-track and cross-track directions for a sine wave input. The Nyquist frequency has a period equal to two ground pixels.

Frequency/Nyquist Frequency	MTF
0.00	1.0
0.25	0.9
0.50	0.7
0.75	0.5
1.00	0.3

The MTF requirements shall be satisfied for modulations of dark to L<sub>typical</sub> and for dark to L<sub>max</sub>, and shall be achieved for every detector of the different IFOV's in the instrument. The MTF's shall be measured at representative points of the VIS, NIR, SWIR, MWIR and LWIR regions (defined in the acronyms list in this specification).

#### 3.4.3 Minimum Quantizing Resolution

A quantizer shall be included in the MODIS-N instrument to generate a digital data stream. The quantization steps shall be sized so that the signal-to-noise requirements for the typical spectral radiances and

temperatures given in Tables 3.3.4.1 and 3.3.4.2 are met. Differential linearity of any signal quantizer shall be better than 0.5 of the least significant bit (LSB).

#### 3.4.4 Transient Response (Bright Target Recovery)

The instrument shall be designed to minimize overshoot and ringing when the IFOV scans across a steep gradient in spectral radiance, from a maximum of  $L_{cloud}$  ( $L_{max}$  for thermal bands) to a minimum of  $L_{typical}$ . For this radiance step change the output signal shall have less than 1% overshoot and the output signal shall settle to within 0.5% of its final value within 2km. This shall be measured with instrument power supply at maximum operating current.

#### 3.4.5 Radiometric Performance

##### 3.4.5.1 Radiometric Accuracy (Spectral & Amplitude)

The MODIS-N digitized and calibrated spectral radiances shall meet in orbit the accuracy requirements delineated below. More than one approach shall be used to verify the calibration accuracy and provide additional confidence in the measurements.

An end-to-end analysis of the total system shall be conducted to show that the system will meet the specified accuracy requirements over the full dynamic range.

The frequency of calibration updates required in orbit for the instrument shall be determined by the contractor. Operational procedures for routine, periodic calibration in orbit shall be developed.

##### 3.4.5.2 Absolute Radiometric Accuracy

The absolute radiometric accuracy for each channel, after ground-based application of calibration data, shall be a constant percentage, given in Table 3.4.5.2, of the typical spectral radiance given in Tables 3.3.4.1 and 3.3.4.2. This accuracy shall apply at all spectral radiance levels from  $0.3L_{typical}$  to  $0.9L_{max}$ , with sufficient calibration levels to characterize the transfer function to achieve this requirement. Accuracies for the "hi" ranges (Table 3.3.4.2) of the nonlinear bands shall be 10%, with a goal of 5%. All accuracies shall be established relative to NIST standards and standard procedures.

Table 3.4.5.2  
ABSOLUTE RADIOMETRIC ACCURACY REQUIREMENTS

	REQT (ONE-SIGMA)	GOAL
BELOW 1000 nm	5%	
1000 - 3000 nm	5%	
ABOVE 3000 nm	1%	
REFLECTANCE CALIBRATION	2%	

What happened to the "GOAL" column in this table? Although I don't support high accuracy calibration as a REQUIREMENT, I think it is a bad idea to leave the GOAL out. We all know that ocean color requires very high radiometric accuracy, so why not indicate this up-front and specify goals.

### 3.4.5.3 Relative Radiometric Accuracy

#### 3.4.5.3.1 Root Mean Square Deviation

The RMS deviation from the mean of the spectral radiance measurements within any channel shall be no greater than the NEdL values given in Table 3.3.4.1 and 3.3.4.2. This applies over the full range of spectral radiance levels.

#### 3.4.5.3.2 Detector to Detector Uniformity

If multiple detectors are used within a spectral band, the calibrated mean output of each detector with respect to every other detector shall be matched to within the values of NEdL given in Table 3.3.4.1 for bands 1-20 and to within the values of NEdL given in Table 3.3.4.2 for bands 21-36. This matching condition shall be met when the instrument views a uniform constant spectral radiance field at levels of approximately  $0.5L_{\text{typical}}$ ,  $L_{\text{typical}}$  and  $2L_{\text{typical}}$  (or  $L_{\text{max}}$ , if  $L_{\text{max}} < 2L_{\text{typical}}$ ). This requirement does not apply in the high temperature ranges of the nonlinear (fire) channels.

#### 3.4.5.4 Uniformity of Response Across a Detector

The system response across each individual detector, in the along-track direction, shall be measured to a resolution at least as fine as 10% of its width. Within the central 80% of the width of the detector this response shall not vary by more than  $\pm 20\%$  of the mean.

#### 3.4.5.5 System Noise Measurements

The signal to noise ratio shall be determined for all bands at a minimum of three equally spaced spectral radiance levels between  $0.3 L_{\text{typical}}$  and  $0.9 L_{\text{max}}$  to characterize the signal dependence of the system noise.

### 3.4.6 Geometric Performance Requirements

An alignment reference cube shall be mounted on the MODIS-N instrument, to allow transfer of alignment from the instrument to the Eos payload mounting plate or to another reference on the spacecraft. The contractor may also use this cube during performance testing.

#### 3.4.6.1 Pointing Knowledge

The angular location of each pixel with respect to the MODIS-N alignment reference cube shall be known to within 60 arc sec at all scan angles. The contractor shall develop an algorithm to relate this knowledge to a cube on the payload mounting plate.

#### 3.4.6.2 Alignment Changes

The alignment of the instrument optical axis with respect to the instrument references and to the instrument mounting surface shall not change by more than 60 arc seconds and the relative alignment of all bands shall remain within specification following any qualification level testing, launch, and in-orbit operation.

#### Pointing knowledge(section 3.4.6.1.)

I do not know what this spec translates to in terms of inter-image registration. The only point I would emphasize in the strongest possible way is the need to obtain sub-pixel registration accuracy in the standard products given to the user, given the vital role of MODIS in detecting and monitoring *change*. The lower our pointing knowledge, the higher the burden in achieving high registration accuracy on the ground.

#### 3.4.6.3 Spectral Band Registration

Registration of any two corresponding pixels from different bands having the same IFOV shall be within  $\pm 10\%$  of an IFOV in the crosstrack and alongtrack directions.

For bands having different IFOV's, alongtrack registration shall be such that the outer edges of the extreme alongtrack channels shall not differ more than  $\pm 10\%$  of the largest (856m) IFOV. Crosstrack registration of pixels of differing IFOV shall be within  $\pm 25$  arc sec (i.e.,  $\pm 10\%$  of an 856m IFOV).

#### 3.4.7 Radiometric Amplitude Stability and Repeatability

Bias errors will be removed from the data during ground processing in order to improve radiometric accuracy. To accomplish this the instrument shall be stable over temperature and time as defined below.

##### 3.4.7.1 Short-Term Stability

Short-term stability as defined here applies to all time scales less than two weeks. The mean radiometric response of each channel, corrected on the ground using in-flight calibration data, shall be not differ by more than  $\pm 1\%$  in the reflectance channels ( $\pm 0.5\%$  for emittance channels) from another response measurement made while viewing the same source operating at equal intensity, but separated by any time up to two weeks, including the effects of perturbations at the orbital period. These stability requirements shall also be met for short-term temperature excursions that may be expected to occur in the MODIS-N instrument.

##### 3.4.7.2 Long-Term Stability

Long-term stability as defined here applies to all time scales between two weeks and five years. The mean calibrated radiometric response, as defined in the previous paragraph, of each channel shall not change by more than  $\pm 2\%$  ( $\pm 1\%$  longer than 3000nm). Because of the impracticability of demonstrating compliance by actual measurement before instrument delivery, compliance can be demonstrated by an estimate of long-term stability based upon short-term tests plus analysis. This analysis shall use measured instrument rates of change as well as vendor supplied subsystem test data.

##### 3.4.7.3 Spectral Band to Spectral Band Stability

The relative amplitude stability between all pairs of spectral bands shall be better than  $\pm 0.5\%$  measured at full-scale and  $\pm 1\%$  at half-scale. Each spectral band shall be exposed to a source and the mean responses determined. To compare outputs between spectral bands, the ratio of the means shall be calculated for each band with respect to a common band. In addition, ratios shall be calculated for selected (approximately ten) pairs of bands which will be used in common retrieval algorithms, e.g., ocean science pairs and land science pairs. These ratios shall remain constant within  $\pm 0.5\%$  at full-scale and  $\pm 1\%$  at half scale over times separated by any interval up to two weeks, including orbital variations.

#### 3.4.7.4 Wavelength Stability

The stability of both the center wavelength and the bandwidth shall be better than 2nm for the VIS bands, and better than 1% of the center wavelength for the other MODIS-N bands. This includes shifts caused by changes of humidity, temperature, pressure, vibrations, or time.

#### 3.4.7.5 Wavelength Accuracy and Precision

Wavelength measurements of the entire system shall be made on the ground, with an absolute accuracy of 0.5nm and a precision of 0.25nm, for wavelengths up to 1  $\mu$ m. The measurement accuracy and precision for all other bands shall scale linearly with wavelength from 1 $\mu$ m.

#### 3.4.8 Stray Light Requirements

##### 3.4.8.1 Stray Light Rejection

The MODIS-N shall reject unwanted scattered and diffracted radiation which affects the radiometric accuracy of the instrument. The instrument shall be designed to restrict stray light from any portion of the spacecraft or other spacecraft subsystem from entering the entrance aperture, solar calibration port or space view port.

For the spacecraft in an operational, nadir-facing attitude, the instrument response to any stray light striking the instrument on any surface (except the entrance aperture and within the instrument FOV) from any angle shall be less than one percent of the illuminating radiance, tested at the typical spectral radiances given in Table 3.3.4.1 and Table 3.3.4.2.

The source or sources used to irradiate the instrument for compliance testing shall have an intensity and view-factor of sufficient size to yield irradiance levels at any surface equal to maximum solar irradiance for any spectral interval within the entire MODIS-N spectral range.

##### 3.4.8.2 Bright Target Within-Field Stray Light

For the VIS and NIR bands, when the MODIS-N views a 21 x 21 pixel bright target of spectral radiance  $L_{cloud}$ , which is surrounded by a region of spectral radiance  $L_{typical}$ , the instrument response shall increase by no more than  $0.004L_{cloud}$  when the brightness of the surround is increased to  $L_{max}$ .

##### 3.4.8.3 Dark Target Within-Field Stray Light

For the VIS and NIR bands, when the MODIS-N views a 21 x 21 pixel dark target of spectral radiance  $L_{typical}$ , which is surrounded by a bright region of spectral radiance  $L_{cloud}$ , the instrument response shall decrease by no more than  $0.004L_{cloud}$  when the brightness of the surround is decreased to  $0.02L_{max}$ .



#### 3.4.8.4 Warm Target Within Field Diffracted Light

For the thermal bands, when the MODIS-N views a target of  $5 \times 5$  pixels at  $L_{typical}$  which is surrounded by a region of cold radiance at  $0.1L_{typical}$ , the instrument response shall increase by no more than 1% when the radiance of the surrounding region is increased to  $L_{typical}$ .

#### 3.4.9 In-Flight Calibration Requirements

An in-flight calibration system, including necessary algorithms, is required. This system shall be capable of calibrating the entire instrument from radiometric input to digital data stream output.

Sources for amplitude calibration include the sun, the moon, and on-board visible and thermal sources. An in-flight solar calibration for the VIS and NIR bands is required; spectral calibration is also required for these bands. All absolute radiometric calibration sources shall fill the aperture.

##### 3.4.9.1 In-Flight Radiometric Calibration

The MODIS-N shall provide for in-flight radiometric calibrations of all bands, providing measurement of changes in gain of the optical, detector and electronics subsystems. In-flight radiometric characterization, i.e., output digital value versus input spectral radiance, shall be made with sufficient accuracy to assure that the calibration requirements delineated in this specification are achieved over the full dynamic range.

##### 3.4.9.2 In-Flight Wavelength Calibration

The MODIS-N shall provide for in-flight wavelength calibration of wavelengths up to  $1\mu m$ . The flight calibration shall be sensitive enough to detect a  $1.0nm$  shift in the shortest wavelength band with a precision of  $0.5 nm$ . The detectable shifts and measurement precision for the other bands below  $1 \mu m$  shall scale with wavelength.

##### 3.4.9.3 In-Flight Reflectance Calibration

The MODIS-N shall provide for in-flight reflectance calibration, using the sun to illuminate a solar diffuser surface which is viewed through the complete instrument optical system.

An on-board capability to monitor the solar diffuser characteristics shall be provided. Knowledge of the diffuser characteristics shall be adequate, when combined with other on-board calibrations, to maintain the calibration and stability requirements of this specification throughout the five year lifetime of the MODIS-N instrument.

Is this good enough, i.e., can we insure  $\pm 2\%$  stability over 5 years (3.4.7.2) using radiometric procedures that are accurate to 5% (Table 3.4.5.2)? *HG*

The contractor shall demonstrate by test that the system provided to monitor the solar diffuser characteristics is sensitive enough and has the stability required to detect changes in the diffuser spectral reflectance in orbit, with a precision and accuracy sufficient to meet the calibration and stability requirements of this specification. This can be demonstrated on a test-to-test basis or by using averages of many tests sequences over periods of weeks to months.

#### 3.4.9.4 In-Flight Lunar Calibration

Provision shall be made for using the moon occasionally as a calibration source.

#### 3.4.9.5 In-Flight Electronics Calibration

The MODIS-N shall consider provision of in-flight calibration of the entire analog and quantizing electronics by inserting an appropriate reference signal, such as a ramp or a stair-step and monitoring the electronic response at appropriate points. Failure in such circuitry shall not disable the signal carrying path.

#### 3.4.10 Miscellaneous Instrument Requirements

##### 3.4.10.1 Passive Radiant Cooler Decontamination & Margin

If a passive radiant cooler is used on MODIS-N, provision shall be made to decontaminate the cooler in the event that outgassing products or other contaminants condense on the cold surfaces. Any cooler doors used in this procedure shall be designed to be fail-safe. The cooler shall be designed with adequate margin for the five-year mission on Eos.

##### 3.4.10.2 Ambient Conditions Operational Limitations

The contractor shall identify and document warnings regarding all sensitive parts, materials, and components and operational instrument limitations. An example of such a warning would be that for the maximum recommended time for ambient temperature operation of detectors normally operated at cryogenic temperatures.

##### 3.4.10.3 Witness Mirrors

Witness mirrors, as required by the Polar Platform General Instrument Interface Specification, shall be provided as part of the instrument.

##### 3.4.10.4 Radiation Induced Noise Immunity

In-flight signal contamination, due to high energy particle induced radiation noise shall be reduced to a level low enough that it does not degrade instrument system performance for an extended period. The contractor shall minimize noise susceptibility by identifying and shielding critical components. Compliance with this specification may be demonstrated analytically.

#### 3.4.10.5 Solar Flux into Optics or Radiators

Under certain unplanned spacecraft attitudes, the radiometer may scan through the sun on several successive scans. The radiometer shall be capable of scanning direct solar input in its 110-degree-wide FOV for a period of thirty seconds per event, and a total of five minutes in five years without detectable performance degradation or reduction in lifetime.

Likewise, any radiator shall be capable of withstanding unplanned direct solar input for a period of thirty seconds per event, and a total of five minutes in five years without detectable performance degradation or reduction in lifetime.

The radiometer shall return to its calibrated condition within one orbit after any exposure to the sun.

Normal, expected solar inputs shall not degrade performance for any portion of the orbit.

### 3.5 COMMAND, CONTROL, COMMUNICATIONS AND TELEMETRY REQUIREMENTS

#### 3.5.1 Command and Control Functions

The MODIS-N electronics system shall be configured to accept ground commands to perform all necessary instrument functions. A complete list of commands required to operate the instrument shall be developed. A definition of the function and necessity of each command shall be provided.

#### 3.5.2 Instrument Data Stream

The instrument data stream shall be sent to the spacecraft communication system. Selected housekeeping and ancillary data shall be included in the data stream.

##### 3.5.2.1 Data Rates

The maximum instrument data rate, averaged over one minute, without any data compression, shall not exceed 15 Mbps. The data shall be buffered to provide a steady data stream independent of scan timing. The night mode shall have a substantially lower data rate than the day mode; additional differing data rates for other modes may be proposed.

##### 3.5.2.2 Data Packet Format

The MODIS-N data shall be packetized within the instrument. The format of the data packets transmitted to the Eos spacecraft is defined in the Eos General Instrument Interface Specification. Data within the packets shall be organized by scan and band in a manner to facilitate quick-look data analyses. Data shall be time tagged with real-time time code often enough to assure compliance with pointing and registration requirements.

### 3.5.3 Instrument Health and Status Monitoring

Telemetry data shall be provided to monitor the health and operating status of the instrument. Additional telemetry signals not included in the data stream shall be available as appropriate on a test connector for use in ground testing.

#### 3.5.3.1 Command Status

The complete command status shall be contained in the telemetry data. Update rates shall be compatible with the frequency of commands which may be sent during testing or flight operation.

#### 3.5.3.2 Engineering Telemetry

Telemetry of instrument temperatures, voltages, currents, and other engineering parameters sufficient to evaluate the condition of the instrument shall be provided. Update rates shall be compatible with anticipated rates of changes of these parameters and shall also be sufficiently frequent to allow anomalous or transient behavior to be assessed. The telemetry information shall be included in the packetized image data stream.

### 3.6 INTERFACE REQUIREMENTS

#### 3.6.1 General

Interface requirements between the MODIS-N and Eos are given in the referenced documents, particularly the General Instrument Interface Specification (GIIS) and the Unique Instrument Interface Specification (UIIS). The GIIS contains interface specifications which apply to all instruments on the Eos spacecraft.

#### 3.6.2 Unique

A UIIS contains interface specifications which are unique to one particular instrument. The spacecraft contractor will bear the primary responsibility to prepare this document, but the MODIS-N contractor shall contribute to the UIIS for MODIS-N.

##### 3.6.2.1 Power Consumption

The orbital average power consumption of MODIS-N shall not exceed 225 watts. The peak power consumption of MODIS-N shall not exceed 275 watts. Survival power shall not exceed 50 watts if the spacecraft-provided cooling plate is used, or 150 watts if it is not used.

### 3.6.2.2 Mechanical Dimensions and Mass

The dimensions of MODIS-N shall not exceed:

Crosstrack	- 1.60 meters
Alongtrack	- 1.00 meter
Height	- 1.00 meter

The MODIS-N instrument shall be designed to mount crosswise on a double Eos payload plate. It may include appendages which overhang another plate, extend past the edge of the spacecraft when deployed, or have limited areas greater than 1.00 meter high. Such appendages, including coolers, doors, shields, diffusers, covers, etc., may exceed the listed dimensions, but are subject to limitation and negotiation. Appendages shall not move through the field of view of a neighboring instrument.

The mass of MODIS-N shall not exceed 200kg.

### 3.6.2.3 Cooling Plate

The Eos spacecraft will provide a cooling plate to MODIS-N, if it is necessary. A description of the plate is in the GIIS. If the MODIS-N contractor requires this plate, mass of the plate will not be charged to the MODIS-N mass; mass of supports for the plate will be charged to the MODIS-N mass.

### 3.6.2.4 View Factors

The following fields of view have been factored into the Eos-A payload accommodations studies. Any views outside of these bounds are subject to negotiation.

#### 3.6.2.4.1 Ground View

MODIS-N will have a clear ground view of five degrees wide along-track and 120 degrees cross-track, centered on nadir.

#### 3.6.2.4.2 Sun View

MODIS-N will be located at the front (velocity) end of the Eos platform. This will provide MODIS-N with the opportunity to view the sun when Eos is passing the south pole into sunlight. Obstructions in front of MODIS-N will be no lower than the plane defined by the nadir face of the Eos payload mounting plates.

#### 3.6.2.4.3 Space View for Passive Cooler and/or Radiometry

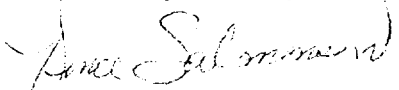
A space view is available along the long side of the Eos platform for a cryogenic radiator. It may also be used for moon or cold sky calibrations.

To: MODIS Team Members  
From: V. V. Salomonson  
Subject: MODIS-N Specifications

Attached are Sections 3.3 and 3.4 of the MODIS-N specifications. Any comments that you have submitted and wherever possible incorporated into this specification. The specification is to be approved by myself and others by November 15. I am providing these few pages so that you have one last (!!) opportunity to check the specification before it is issued. It is my opinion that the specification has gone as far as it can go in providing a MODIS-N instrument that is responsive to the scientific community and still be within cost, schedule, etc. Parenthetically I must comment that MODIS-N is sufficiently prominent in the Eos scheme of things to be addressed specifically the OMB because it is the pacing instrument in the overall Eos schedule.

**PLEASE REVIEW THIS INFORMATION CONFIDENTIALLY AND DISCRETELY. IT SHOULD NOT BE DISCUSSED WITH ANYONE THAT MAY RELAY THE INFORMATION TO A POTENTIAL BIDDER ON THE MODIS-N CONTRACT. JUST SEND ANY FINAL, LAST MINUTE THOUGHTS YOU MIGHT HAVE TO ME, BILL BARNES OR LOCKE STUART USING THE USUAL MEANS OF COMMUNICATION.**

Thanks for your many efforts.



Vincent V. Salomonson  
MODIS Team Leader